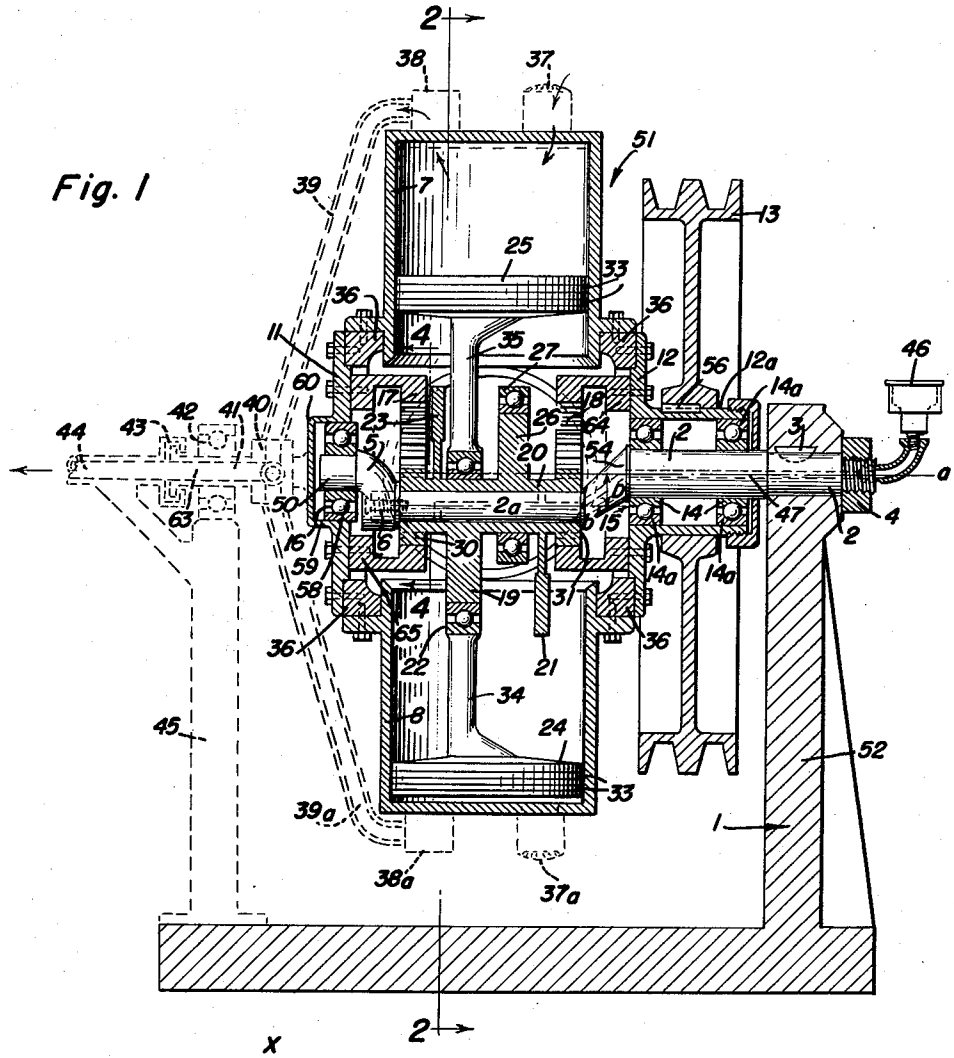
July 13, 1954 A. Z. RICHARDS, JR 2,683,422

ROTARY ENGINE OR COMPRESSOR

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Fig. 1



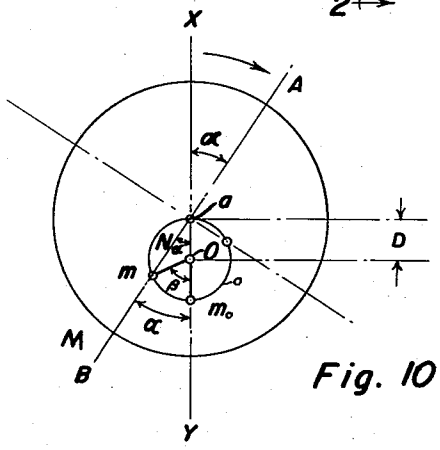


Fig. 10

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Fig. 2

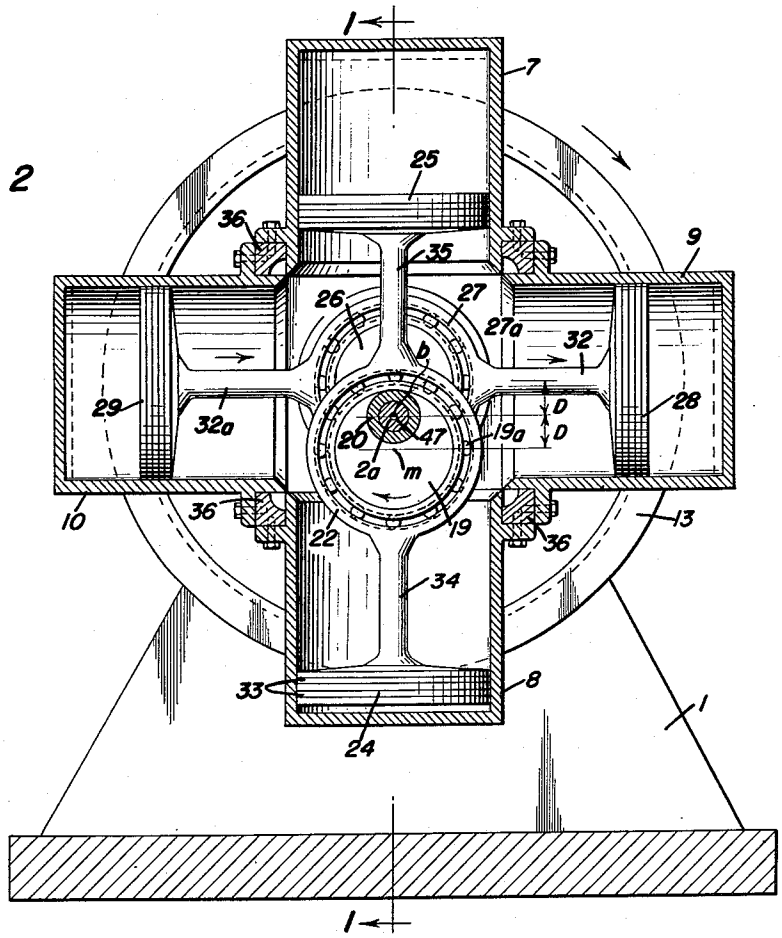
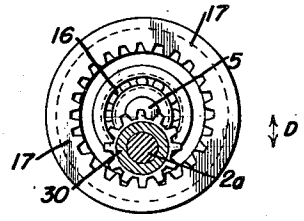


Fig. 4



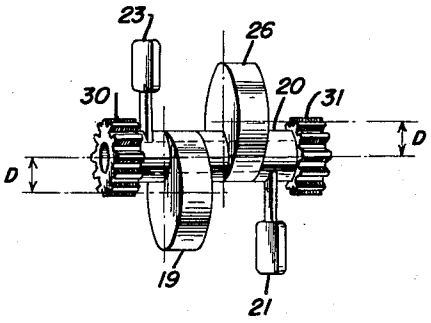


Fig. 3

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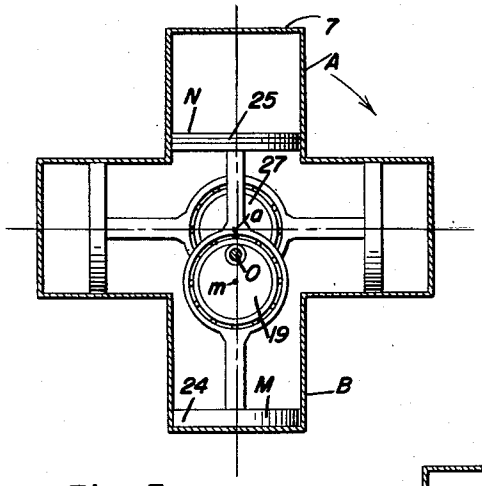


Fig. 5

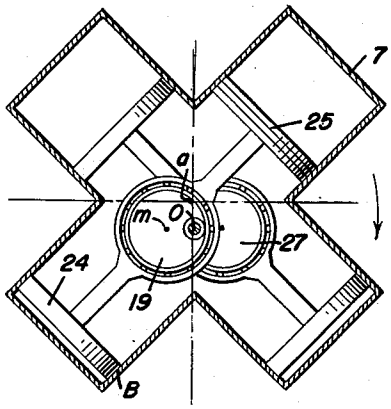


Fig. 6

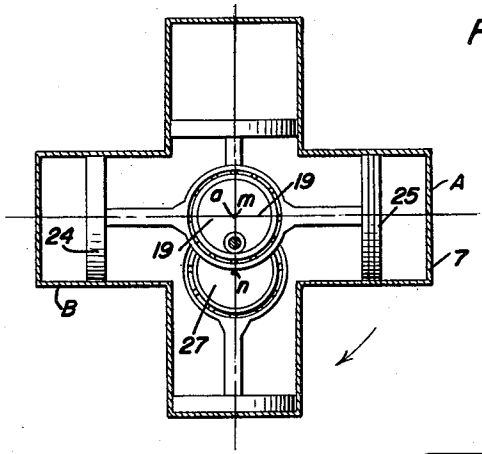


Fig. 7

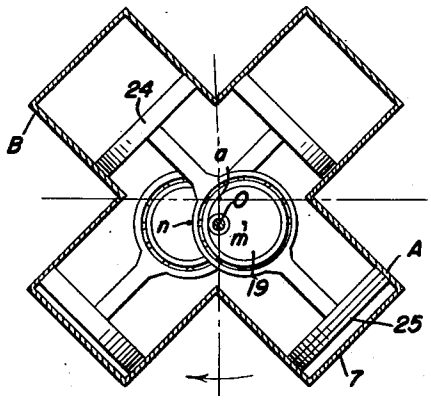
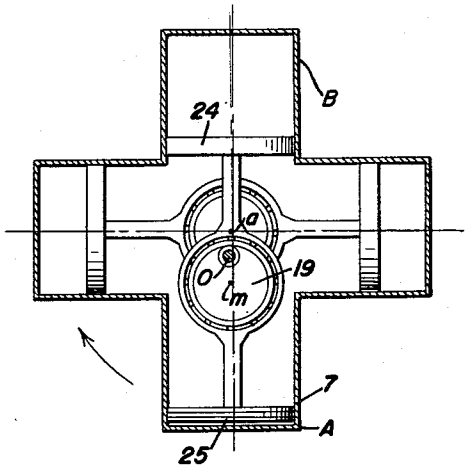


Fig. 8

Fig. 9



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2,683,422

ROTARY ENGINE OR COMPRESSOR

Albert Z. Richards, Jr., Salt Lake City, Utah

Application May 19, 1950, Serial No. 162,855

7 Claims. (Cl. 103—161)

1

This invention relates to mechanisms using reciprocating pistons and cylinders such as steam or internal combustion engines or such as pumps or compressors and it has for its main object to provide a mechanism in which the relative reciprocating movement between the pistons and cylinders is transformed into a rotary movement of constant angular velocity by means of an intermediary mechanism which performs merely a rotary movement with a constant angular speed.

It is a further main object of the invention to provide an arrangement in which no acceleration or deceleration of the parts occurs during the conversion of movement from a relatively reciprocating movement into a rotary movement so that the mechanism will operate with the smoothness and uniformity which has hitherto merely been obtained with rotating engines such as turbines or electric motors.

A further object of the invention consists in providing a mechanism consisting of cylinders and pistons reciprocating therein which is perfectly balanced and in which the composite masses of each set of pistons as well as the composite masses of each set of cylinders find a center of gravity in the center of rotation for the set.

A further object of the invention consists in providing a rotating engine, compressor or pump with two rotating systems, one of said systems being the cylinder set of the engine while the other system is the set of pistons reciprocating within said cylinders, said two sets being rotatable around axes which are offset with respect to each other.

A further object of the invention consists in providing a rotating engine with a set of cylinders and a set of pistons reciprocating within the cylinders, each having a separate center of rotation, said centers being offset with respect to each other, and the pistons being linked to their center of rotation in such a manner that a center point on each piston may revolve around the center of rotation of said piston set along a circle, the radius of which is equal to the distance between the centers of rotation of the cylinder set and the piston set.

Further and more specific objects of the invention will be apparent from the following detailed specification.

The invention is illustrated in the accompanying drawings showing one embodiment thereof by way of example. It is however to be understood that the example shown intends to illustrate mainly the principle of the invention and the best mode of applying this principle. Modifications of the example shown are therefore not necessarily departures from the principle of the invention, especially as the invention has been illustrated more or less diagrammatically and no attempt has been made to survey those embodiments and modifications thereof by means of which the invention may be carried into effect.

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In the accompanying drawings:

Figure 1 is an elevational sectional view of one embodiment of the invention, merely those parts which have a direct connection with the invention being shown in detail while further additions which are relative to the functioning of the example shown as a compressor are shown merely in dotted lines. The section showing the figure has been taken along line 1—1 of Figure 2.

Figure 2 is a sectional elevational view of the embodiment of the invention shown in Figure 1, the section in this case being taken along line 2—2 of Figure 1.

Figure 3 is an isometric view of one detail of the invention.

Figure 4 is an elevational partly sectional view showing a detail, the section being taken along line 4—4 of Figure 1.

Figures 5 to 9 are diagrammatic views showing different phases of movement of the cylinders and pistons used according to the invention, the views illustrating the position of the various parts during rotational movement through 180°.

Figure 10 is a diagram of the angular motion performed.

As has been above explained the principle of the invention consists in providing a rotatable multi-cylinder unit, rotating with constant angular velocity around a fixed axis and a rotatable piston unit, the pistons of which are movable within the cylinders of the cylinder unit which piston unit rotates at a constant angular velocity around an axis which revolves with constant angular velocity around a second fixed axis, which is offset with respect to the first named fixed axis around which the cylinder unit rotates. Therefore the movement of the cylinders and pistons is throughout a rotational movement with constant angular velocity for both movable units in which the relative rectilinear and reciprocating movement between the pistons and cylinders translates itself into a rotational movement without any mechanism comprising a reciprocating member and in which, provided conditions are kept constant, no variation of the

angular speed occurs. The piston motor is thus adapted for very high speeds and is capable of running with a uniformity and smoothness which is usually only obtainable in connection with rotational motors, such as a turbine or an electric motor. Moreover, the two above named units move constantly and without acceleration or deceleration around a center with unchanged speed, while the ratio between the speeds also remains constant.

When considered from a cinematic standpoint the above described movement of the cylinders around a fixed center and of the pistons around a center revolving around a second fixed center produces a regular reciprocating movement of the pistons relatively to the cylinders on account of the fact that the combination of two rotational movements around centers which are offset for a distance, while one center is revolving around the other center, produces a differential movement which is rectilinear and which is equal to twice the diameter of the circle described by the revolving center around the fixed center. It is thus seen that, while all movements of the two sets, one including the pistons and the other including the cylinders, are angular movements at constant speed, the relative movement between the pistons and the cylinders may be a rectilinear movement at increasing and decreasing speed equal to the desired piston stroke within the cylinder.

Likewise, when considered as a power delivery unit it will be clear that in such a unit, conversely, the reciprocating linear movement of the pistons within the cylinders may be split or decomposed into two angular components or movements of constant speed, one of said movements being imparted to the cylinder unit around the center and one of said movements being imparted to the piston unit, the center of linkage of the pistons revolving at a constant angular speed around a second center which is fixed and which is offset from the first mentioned center around which the cylinders revolve.

The above stated principle is illustrated diagrammatically in Figures 5 to 9 in which figures five different positions or phases of movement of the cylinders and of the pistons are shown, while Figure 10 shows the geometrical relations of the centers.

A cylinder unit, the cylinders A and B of which rotate around the center *a*, is shown in different successive positions. Likewise a piston unit comprising the two pistons M, N cooperates with the two cylinders B and A, and rotates around the center O, the center of the piston system M, N being designated by m. Obviously, while the cylinder A moves through an angle α (Figure 10) around the center or axis *a*, the center *m* of the piston system M, N moves through an angle β around O.

As will be seen from Figure 10, X—Y represents a reference line marking the initial position of the cylinder and piston systems.

Let it be assumed that the cylinder system indicated by line A—B has moved through the angle α. Then also the piston system must have adopted this position, as the longitudinal axes of the cylinder system and of the piston system are always identical.

The piston system, however, moves with its center *m* moving along a circle *o* of radius D, the center of the circle being at O at a distance from axis *a* equal to D. Therefore the angle β through which the point *m* has moved along the circle

around the center O will differ from the angle α through which the axis of the cylinders has moved around the center *a*. As the angle mam_o is equal to α and as mam_o is the peripheric inscribed angle subtended over the arc mm_o while β is the center or sector angle subtended over the same arc, it follows that

$$\alpha=\frac{\beta}{2}$$

As the angles covered simultaneously are proportional to the angular speeds it will be clear that if the cylinders rotate at a constant angular speed around the center *a* the piston system rotates at two times the speed around the center O.

The movement of the cylinder and piston system is clearly seen from the figures in which the rotation of the cylinder system A—B around 180° is shown. While the cylinder system A—B moves through 180° the center *m* of the piston system M—N is moved through 360° thus moving the pistons within the cylinders through a distance which is equal to $4\times Om$.

It will be noted that the angular speed of the cylinders is always exactly one-half the angular speed of the center *m* of the piston system.

In the figures four cylinders are shown, but it will be clear that any number of cylinders may be used. Moreover it will also be noted that with four cylinders the torque which is exercised if the cylinders are those of an internal combustion engine, is always the same and therefore the speed of rotation always remains constant.

The example illustrated in Figures 1 to 4 shows merely the mechanism for moving the piston and the cylinder systems, but it does not include the means for operating the cylinders, such as the valves, the control mechanisms for the valve, the fuel supply, the manifold, etc., or any other means for producing pressure on the pistons by means of steam or fuel, the combustion of which is initiated within the cylinder, or the means for introducing a pressure fluid such as steam, air or the like into the cylinders.

It is manifest that the invention is not connected with the driving of the pistons within the cylinders, but is merely relative to the conversion of the motion imparted to the pistons within a cylinder system into a rotational movement.

Likewise, also, the rotational movement may be imparted to the pistons by rotating the assembly in which case the pistons would exercise pressure on a fluid within a cylinder as is the case, for instance, with a compressor or with a fluid pump.

However, in order to show one complete example the connection of the cylinders with a fluid conducting system is shown in dotted lines in Figure 1, but it is to be understood that this portion of the system is a portion which has to be adapted to the special purpose for which the unit is constructed, in this example to an air compressor, and to the means of exercising pressure on the piston within the cylinder or of exercising pressure on the fluid within the cylinder.

The invention comprises essentially a stationary shaft **2** which is provided with an offset section **2***a* the axis *b* of the offset portion **2***a* being arranged at a distance D from the axis *a* of the stationary shaft **2**. Around the stationary shaft a rotor generally indicated at **5**1 is rotating, which rotor consists in the example shown of four cylinders **7, 8, 9, 10**, forming a constructive unit. Within the cylinders **7, 8, 9, 10**, the pistons **25, 28, 24** and **29** reciprocate.

The stationary shaft **2** is rigidly held within

a frame 1 comprising uprights or standards 52 provided with means for holding the shaft. Preferably the shaft 2 is held within a bore of the standard and is firmly secured therein by means of a key 3 and a nut 4.

The shaft essentially comprises the cylindrical section 47 carrying a ball bearing 15 to be described below and the offset shaft section 2a which is joined to section 47 by means of a conical junction piece 54. The axis b of the offset shaft section 2a is below the axis a of shaft 2 in the example shown and is arranged at a distance D as above mentioned.

The other end of the offset section 2a of the shaft carries a bracket 5 which is removably fixed to the section 2a and at the end of which a pin 50 projects, the axis of which is aligned with the axis a of shaft 2. The bracket therefore must be of such length that it forms a junction piece bridging the distance D. The bracket 5 is fixed on the end of the offset shaft section 2a by means of a bolt 6.

The cylinder unit consisting of the four cylinders 7, 8, 9, 10, comprises, in addition to the cylinders, the end plates 11 and 12 and the cage block 36 to which the cylinders and the end plates are fastened by means of screw bolts. The end plate 12 is provided with a central sleeve 12a which is coaxial with the shaft 2 and which carries the outer rings 14a of the ball bearings 15 which cooperate with the inner rings 14 on section 47, the balls being inserted between said outer and inner rings. On said sleeve 12a a pulley 13 is mounted which is shown as a V-belt sheave with V-shaped grooves into which the belts may be inserted.

The belts transmit the power from the sleeve to the machine or unit driven by the rotary engine or they transmit the power from a rotary engine to the cylinder system and piston system in the event that the two latter systems form part of a compressor or pump. The pulley 13 therefore always rotates with the rotor 51 and is fixed to the sleeve 12a by means of a key 56.

The end plate 11 may be a closing plate to close the cylindrical recess 59 within which a ball bearing 16 is held surrounding the pin 50. The outer rings 58 of the ball bearings are mounted within the cylindrical recess 59.

The center portion 60 of end plate 11 may however be integral with the projecting hollow stem or shaft 41 indicated in dotted lines which is pierced by a channel 63 and which is supported and journaled in the ball bearing 42 carried by an upright 45 of the frame 1.

On this hollow stem a distributor box 40 is mounted which establishes communication between the channel 63 in the interior of the hollow stem or shaft and the pipes 39 and 39a which lead to valves 38, 38a communicating with the interior of the cylinders.

In the example shown further valves 37, 37a are provided which form the suction valves of a compressor. The compressed air is delivered through the valves 38, 38a and through the pipes 39, 39a and finally through the channel 63 to the unit where the compressed air is stored or utilized.

A packing gland 43 is indicated diagrammatically near the end of the hollow stem 41 which connects the rotating stem 41 with a stationary pipe 44. The latter is somehow carried by the upright 45 or by some other stationary member.

A corresponding arrangement would have to be made in the event that the cylinder rotor is part of an internal combustion engine.

The piston unit cooperating with a cylinder unit consists of the four pistons 24, 25, 28, 29, each provided with a suitable number of piston rings 33, the pistons of opposite cylinders, as already explained, being joined in pairs 24, 25, 28, 29 respectively by the piston rods 34, 35 and 32, 32a respectively. The piston rods 34, 35, for example, are joined by the ring 22 of the eccentric 19, while the piston rods 32, 32a are joined by the ring 27 of the eccentric 26. The eccentrics 19 and 26 are integral with and mounted on the sleeve 20 which surrounds the offset stationary shaft section 2a and which is rotatable thereon.

Each of the eccentrics is offset with respect to the axis b of the offset shaft section 2a for a distance which is equal to the distance D between the axes a, b of the shaft sections 2, 2a.

Therefore, as will be clear, the center of each eccentric moves in a circle around the axis b and said circle is tangential to the axis a of the shaft 2.

It will also be seen that if four cylinders are arranged the operational phases of which show a cyclic distribution the two eccentrics which are operated by the pistons moving within the cylinders will preferably have to be positioned on the sleeve in such a way that they show a phase difference of 180° whereby on account of the opposite phases in the two cylinder pairs with connected piston pairs a constant torque and a complete balancing of the weight results.

The sleeve 20 is driven, as seen in Figures 3 and 4, by means of gear wheels 30, 31 which mesh with gear wheels with internal teeth 17, 18 integral with an annular intermediary skirt 64, 65 provided with inwardly projecting flanges which are fixed on the end plates 11, 12. The ratio of the gear wheels 30, 17 and 31, 18 is 1:2 as will be clear from the fact that the angular speed of the center m must be twice the angular speed of the cylinder movement around the axis a as has been explained.

The sleeve 20 also, in addition, supports and is solidary with two balancing weights 21, 23 which are mounted on suitable arms and which are provided for securing a perfect balance of the moving weights.

Such a perfect balancing of the weight of the moving parts occurs automatically by itself as the center of gravity of the composite masses of the two eccentrics and of the piston rods and pistons is in the axis of shaft 2a. This will be clear from the fact that the pistons, eccentrics, etc. are all equidistant from the said shaft axis b around which the piston rotor revolves. Likewise the center of gravity of the composite masses of the cylinders or cylinder assembly is in the axis a of stationary shaft 2 around which it revolves.

Let it now be assumed that the cylinders are for instance the working cylinders of an internal combustion engine with the piston 24 in cylinder 8 (B in Figures 5 to 9) in its position shortly after ignition and at the start of the expansion stroke, as is shown in Figure 5 for example, then the outward movement of the piston 24 in its cylinder develops a torque causing rotation of eccentric 19 and the center m of the eccentric is forced to move along a circle around the axis O in Figure 5.

When the center m of the eccentric has moved through 90° the cylinder B is in the position shown in Figure 6, the sleeve 20 having moved also through 90°. The rotation of gear wheel 30, 31 through 90° rotates gear wheel 17, 18 through 45° and the piston 24 is therefore one-fourth of its way down on its expansion stroke in the cyl-

inder which has assumed the position shown in Figure 6.

Upon further advance of the piston 24 in cylinder B the center *m* of the eccentric 19 of the piston system reaches the point where it is coincident with the center *a* of the cylinder system. As will be seen by comparing Figures 5 and 7 the point *m* in this case has moved through an arc of 180°. The piston 24 is then half way down toward the end of its stroke. Finally as shown in Figure 9 when the piston 24 has arrived at the end of its stroke the center *m* has covered an arc of 360°, but now the positions of the cylinders A, B is reversed, as the cylinder system A—B has moved during this time only through 180° as can clearly be seen from the figures.

While the piston 24 made its stroke from its ignition position as shown in Figure 5 to its end position shown in Figure 9 the second piston 25 and cylinder A moved outwardly from its innermost position in the compression phase of the internal combustion engine.

It will be seen that the two other cylinders cooperate in a like manner with a phase difference which corresponds to the phase difference of 180° between the two eccentrics 19 and 26 on the sleeve 20. In practice it will be preferable, if the engine is of the four stroke type having an even number of cylinders, to use at least two axially aligned sets of cylinders, for instance, to arrange two sets of four cylinders each, arranged in an axially spaced position along the common axis *a*. Their firing order, if the cylinders of the first set are numbered 1, 2, 3, 4 and the cylinders of the axially spaced set are numbered 5, 6, 7, 8 would then be 1, 2, 3, 4, 5, 6, 7, 8.

It is thus seen that, according to the invention, each of the parts performing a rectilinear reciprocating movement with respect to each other, such as the cylinders and pistons of the engine or compressor, performs an angular movement with constant speed around the two centers *a* and O, the movement of the pistons and cylinders being however different and occurring at different constant speeds. This difference is obtained by the movement of the piston system around an axis which is displaced with respect to the axis around which the cylinder system turns the center of the piston system describing a circular movement along a circle with a diameter which is twice the distance between the centers. The invention therefore eliminates the acceleration and the deceleration of the movement and the corresponding necessity of an equalization of the movement by means of a flywheel or the like, as well as the strain which acts on the moving parts and which is due to the constant acceleration and deceleration.

Moreover the system is a perfectly balanced system in which the centers of gravity of the rotating system are coincident with the centers of rotation so that a high speed of rotation can occur without causing vibrations or other irregularities.

It will be clear that the unessential parts of the invention may be changed without in any way departing from the essence of the invention as defined by the annexed claims.

Having described the invention, what is claimed as new is:

1. A movement translation system for rotary engines or pumps, comprising a first stationary shaft section, a second stationary shaft section, eccentric with respect to the first stationary shaft section, a set of cylinders, radially arranged around the axis of the first stationary shaft section, said cylinders being closed on the outside and open on the inner side, means rotatably supporting the said set of cylinders on said first stationary shaft section, a set of pistons reciprocating within said cylinders, said set of pistons being rotatable around the axis of the second stationary shaft section, means rotatably supporting said set of pistons around the last mentioned axis, said last mentioned means having a point thereon which, during operation, will generate a circle having its center in the axis around which the set of pistons rotate, means to rotate the cylinder set around its axis of rotation and means to interconnect the cylinder set with the set of pistons, said last named means including a gear connection providing a proportional reduction ratio in angular velocity between the cylinder set and the means supporting the set of pistons.

2. A rotary engine or pump comprising a stationary shaft consisting of a first stationary shaft section provided with a cylindrical supporting portion and a second stationary shaft section, adjacent thereto, being offset with respect to the first named shaft section and forming a cylindrical supporting section, a set of cylinder pairs, the cylinders of each pair being aligned along their longitudinal axis and facing each other, the cylinders of the set being radially disposed with respect to and arranged to rotate around the axis of the first stationary shaft section, each cylinder of the set being closed at its outer end and open at its inner end facing the other cylinder of the pair, a set of piston pairs reciprocating within said cylinder pairs, the pistons of a piston pair reciprocating within a cylinder pair being rigidly connected with each other, and the set of piston pairs being rotatable around the axis of the offset shaft section, means rotatably supporting said set of cylinder pairs on the supporting portion of said first stationary shaft section, means rotatably supporting said set of piston pairs on the cylindrical supporting section of the said offset stationary shaft section, a point on said last named means, during operation, generating a circle, the center of which is located in the axis of the offset shaft section, means interconnecting the means rotatably supporting the cylinder set and the means rotatably supporting the piston set including gear wheels maintaining the angular speed of the means supporting said set of piston pairs at a value twice the angular speed of the set of cylinder pairs.

3. A rotary engine or pump as claimed in claim 2, wherein the means rotatably supporting the piston set on the offset shaft section include a hollow bearing sleeve provided with an eccentric for each rigidly connected pair of pistons, eccentric rings on each pair of rigidly connected pistons cooperating with said eccentrics, said hollow bearing sleeve being further provided with one of the gear wheels maintaining the angular speed of the piston set at a value twice the angular speed of the cylinder set, and wherein the means for supporting the cylinder set on the first stationary shaft section include a further hollow sleeve journaled on the supporting sleeve of the first stationary shaft section, and are connected with an internal gear wheel forming the second one of the above mentioned gear wheels maintaining the angular speed of the means supporting said piston set at a value twice the angular speed of the cylinder set, the said internal gear wheel meshing

with the first named gear wheel connected with the above named hollow bearing sleeve.

4. A rotary pump or engine comprising a stationary shaft, including a number of spaced sections, a first section and an end section being coaxial and spaced from each other, and a second section joining the first and the end sections, being offset and eccentric with respect to said first and end sections, a set of radially arranged cylinders closed at their outer and open at their inner ends, forming a cylinder block unit, rotatable around the axis of the first named shaft section, but substantially surrounding the second offset shaft section, laterally projecting means on said cylinder block journaling and supporting the cylinder block rotatably on the spaced first and end sections of the stationary shaft, a set of pistons, each piston of the set being reciprocable within one of the cylinders, and each piston being provided with a piston rod, said set of pistons being rotatable around an axis coincident with the axis of the second offset shaft section, a hollow sleeve rotatable on said offset shaft section supporting the reciprocable pistons, each piston rod being guided during rotation by means having a point thereon, generating, during operation, a circle the center of which is located on the axis of rotation of the piston set, each piston, during the rotation of the piston set, being thus reciprocated within its cylinder, and means maintaining the rotation of the piston set and the rotation of the cylinder set in correct proportion for reciprocation of the pistons within the cylinder, said means including meshing gear wheels on the cylinder block and on the hollow sleeve respectively, said gear wheels having a gear ratio maintaining the angular speed of the sleeve supporting the piston set at a value twice that of the angular speed of the cylinder block.

5. A rotary pump or engine comprising a stationary shaft, including a number of spaced sections, a first section and a coaxial end section spaced from each other, a second section joining the first and the end section, being offset and eccentric with respect to said coaxial first and end sections, a set of radially arranged cylinders, closed at their outer and open at their inner ends, forming a cylinder block unit, rotatable around the axis of the first named shaft section, but substantially surrounding the second offset shaft section, the cylinders being arranged in coaxial

pairs facing each other, means laterally projecting from said cylinder block unit and including bearing sleeves journaling said cylinder block unit rotatably on the first and end sections of the stationary shaft, a set of piston pairs, each piston pair being reciprocable within one of the coaxial cylinder pairs, and being provided with a piston rod, rigidly connecting the pistons of each piston pair with each other, the piston pairs being rotatable around the axis of the second offset shaft section during their reciprocation within the cylinders, means supporting said piston pairs on the second offset shaft section and controlling their movement relative to the offset shaft section, said last named means including a hollow bearing sleeve rotatable on the second offset shaft section and provided with an eccentric disk for each pair of pistons, an eccentric on each piston rod connecting a piston pair cooperating with one of the eccentric disks and guiding the pair of pistons during rotation, means imparting to said eccentric disks an angular speed twice as high as the angular speed of the cylinder block, said means including a gear wheel carried on the end of the hollow bearing sleeve and a meshing gear wheel with internal teeth projecting inwardly from the lateral supporting means of the cylinder block, and a power transmitting pulley fixedly connected with the rotatable supporting means of the cylinder block.

6. A rotary pump as claimed in claim 3, comprising in addition a hollow rotating shaft attached to the rotatable cylinder system for fluid transmission, and distributing pipes leading from the hollow shaft to the cylinders.

7. A rotary engine as claimed in claim 3, wherein the hollow bearing sleeve is in addition provided with balancing weights to counteract the weight of the eccentric and to produce a perfectly balanced rotational unit.

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